

assignment 1

by William Carey

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TIME SUBMITTED	27-APR-2021 11:07AM (UTC+0100)	WORD COUNT	1350
SUBMISSION ID	150666073	CHARACTER COUNT	8240

Course: HNC Electrical and Electronic Engineering
Module: SGEE5002 Electrical Principles, Methods and Simulation
Assignment Title: Analysis, Simulation, and Evaluation of electric circuits and systems
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University number: 1910601
Date Submitted: 26/04/2021
Word Count: 1274 words

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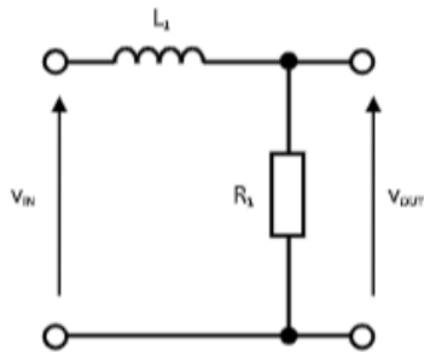
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Task 1



$V_{IN} (Us) = 12V$ $L = 1H$ $R = 1000ohms$

$$R/sL + R \times Us = 1/s$$

$$1000/1 + 1000 \times 12 = 11.988/s$$

$$Us - 1/s = \text{step input} \quad Ys = R / sL + R \times 1/s = R / s(sL + R)$$

Incorrect

$$(R/L) / s(s + R/L) \quad \text{Laplace transform table} = a / s(s + a)$$

$$a = 1/T = 1/0.001 = 1000$$

$$T = L/R = 1/1000 = 0.001\text{sec}$$

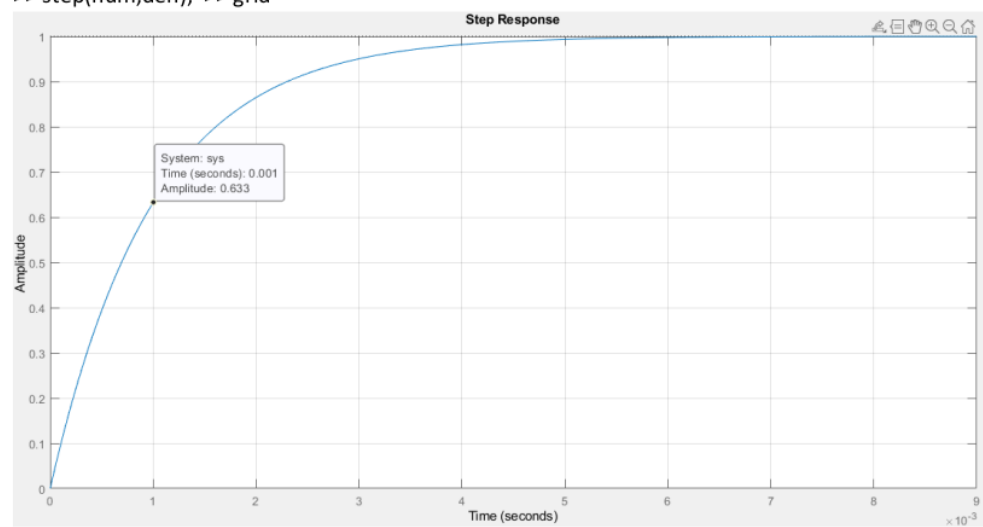
$$Ys/Us = 1/T(s) + 1 = 1 / 0.001 + 1$$

Calculation then placed into Matlab to produce a graph:

```
>> num = [1];
```

```
>> den = [0.001 1];
```

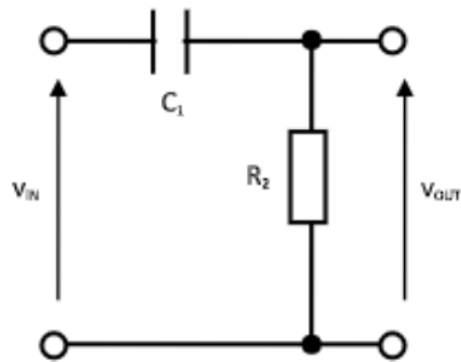
```
>> step(num,den); >> grid
```



Calculated time constant (secs)	Simulated time constant (secs)
0.001	0.001

As can be seen from the previous graph, it displays how the coil in the circuit charges over time, reaching a critical point where its 'capacity' is reached and will continue to essentially hover at this value until discharge. The value that is charged in this circuit is current as it is a coil.

Task 2

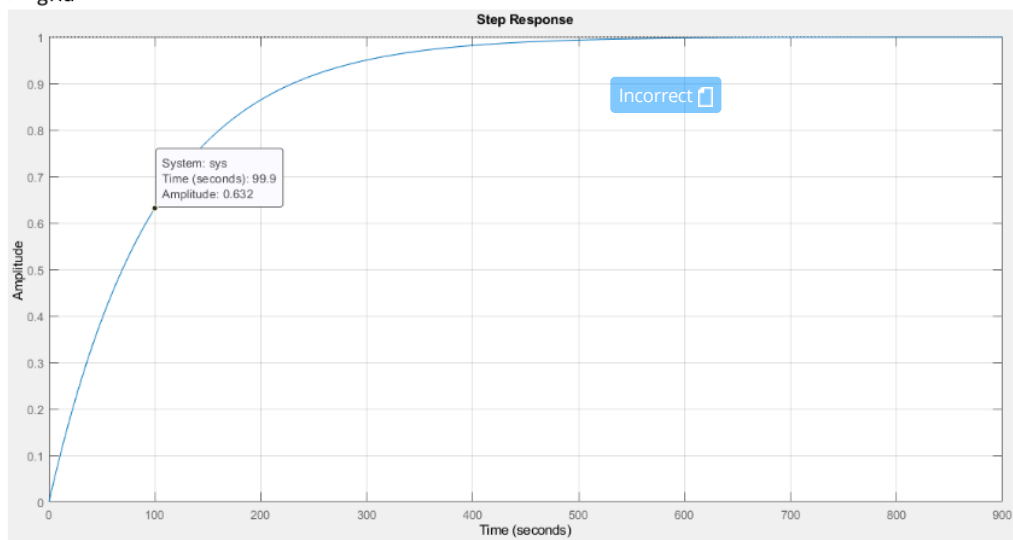


$V_{IN} (Us) = 12V$ $sC = 100mF$ $R = 1000ohms$

$T_{or} = 100mF \times 1000 = 100sec$

$H(s) = 1 / RCs + 1 = 1 / 100 \times 1$

```
>> num = [1];
>> den = [100 1];
>> step(num,den);
>> grid
```



The data point on the graph is marked at one time constant.

Calculated time constant (sec)	Simulated time constant (sec)
100	99.9

As is similar to the previous task, the circuit charges then reaches a critical point, the difference being that it's a capacitor and so charges with voltage instead of current.

Task 3

$V_{in} (U_s) = 12V$ $sL = 1H$ $R = 1000ohms$

Frequency response = $H(s)$ $s = j\omega$

$$H(j\omega) = |H(j\omega)| \angle \theta(j\omega)$$

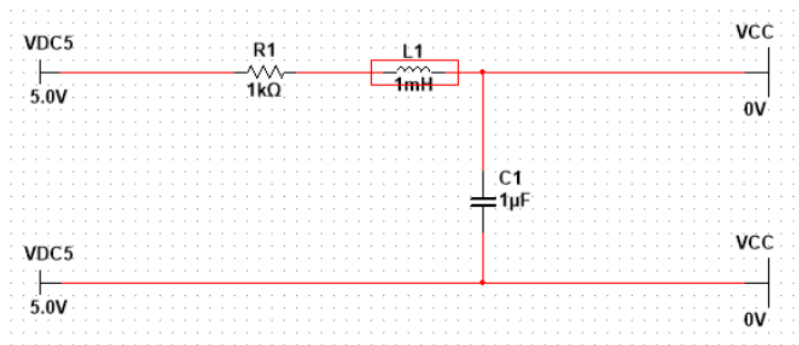
$$Y(s) / X(s) = (R/L / (s + R/L)) = H(s) \quad \text{Transfer function} = H(s) = (\omega_c / (s + \omega_c))$$

$$(1000/1) / (s + (1000/1)) = 1$$

You have worked this out correctly, well

Task 4

Task 5



$R = 1k$ $L = 1m$ $C = 1u$

$$\text{Laplace} = Y(s) = (1/sC) / (R + sL + (1/sC)) X(s)$$

$$\text{Standard second order transfer function} = H(s) = (1/LC) / (s^2 + (R/Ls) + (1/LC))$$

$$\text{Transfer function} = H(s) = (K\omega_n^2) / (s^2 + (2 \times \Sigma \omega_n s) + \omega_n^2)$$

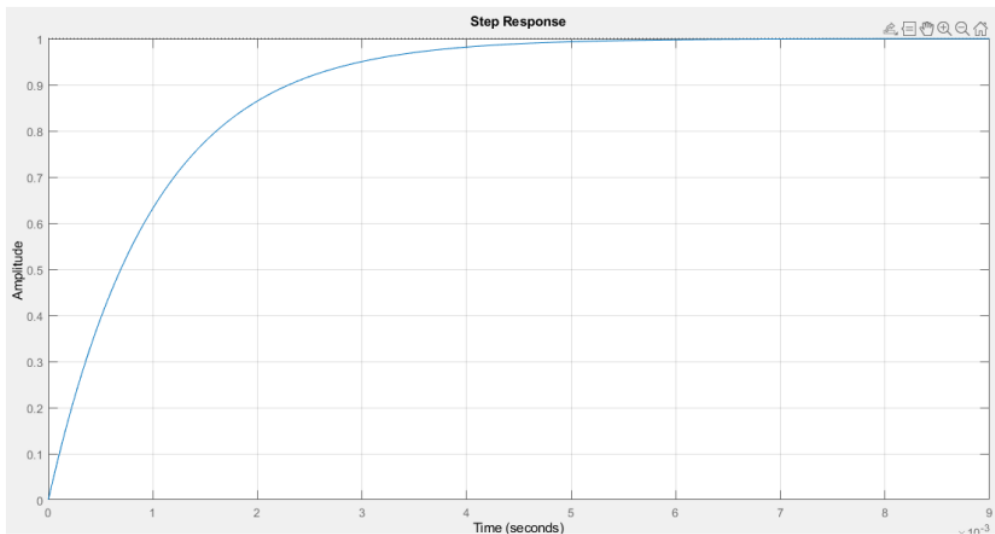
$$\omega_n = 1/\sqrt{LC} = 1/\sqrt{(1 \times 10^{-3}) \times (1 \times 10^{-6})} = 1,000,000,000$$

$$\Sigma = \frac{1}{2} \times R/L \times 1/\omega_n = \frac{1}{2} \times (1000/(1 \times 10^{-6})) \times (1/1000000000) = 0.5$$

Since Σ (sigma) is less than 1, it means that the signal is over damped

When placed into matlab it is coded in the following way:

```
>> num = [1000000000];
>> den = [1 1000000 1000000000];
>> step(num,den);
Grid
```



When compared to the calculated results and the determination of whether the graph would display an overdamped circuit, it can be seen that this is true although the result is very close to that of a critically damped circuit.

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Task 6

$R = 1500\Omega$ $L = 5H$ $C = 1mF$

$$H(s) = (s \cdot 1/RC) / (s^2 + (1/RC)s + 1/LC)$$

$$= (s \cdot 1/1500 \times 0.001) / (s^2 + (1/1500 \times 0.001)s + (1/5 \times 0.001))$$

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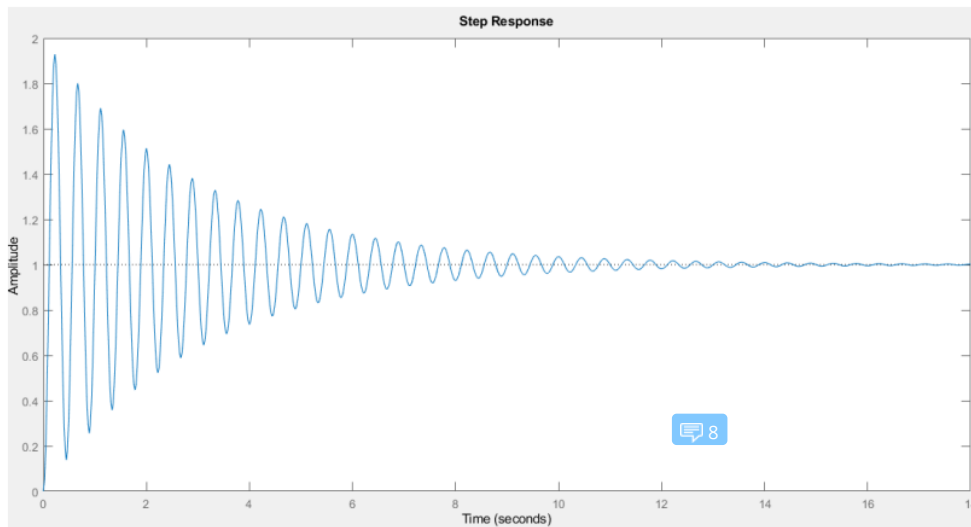
$$= 0.666s / s^2 + 0.666s + 200$$

$$\omega_n = 1/\sqrt{LC} = 1/\sqrt{5 \times 0.001} = 14.142 \text{ rad/s}$$

$$\Sigma = (1/2R) \sqrt{L/C} = (1/2 \times 1500) \sqrt{5/0.001} = 0.0235$$

Since the sigma is less than one, this will indicate that the circuit is underdamped which should be reflected in the graph produced through the matlab simulation, below is the code used to do this:

```
>> num = [200];
>> den = [1 0.666 200];
>> step(num,den);
```



Task 7

$R = 1k$ $L = 1mH$ $C = 1\mu F$

$H(s) = (1/LC) / (s^2 + (R/Ls) + (1/LC))$ (transfer function)

$H(s) = (1 \times 10^{12}) / (1 + (1 \times 10^6) + (1 \times 10^{12}))$

$1/LC = 1000 / 0.001 \times (1 \times 10^{-6}) = (1 \times 10^{12})$

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$R/L = 1000 / (1 \times 10^{-3}) = (1 \times 10^6)$

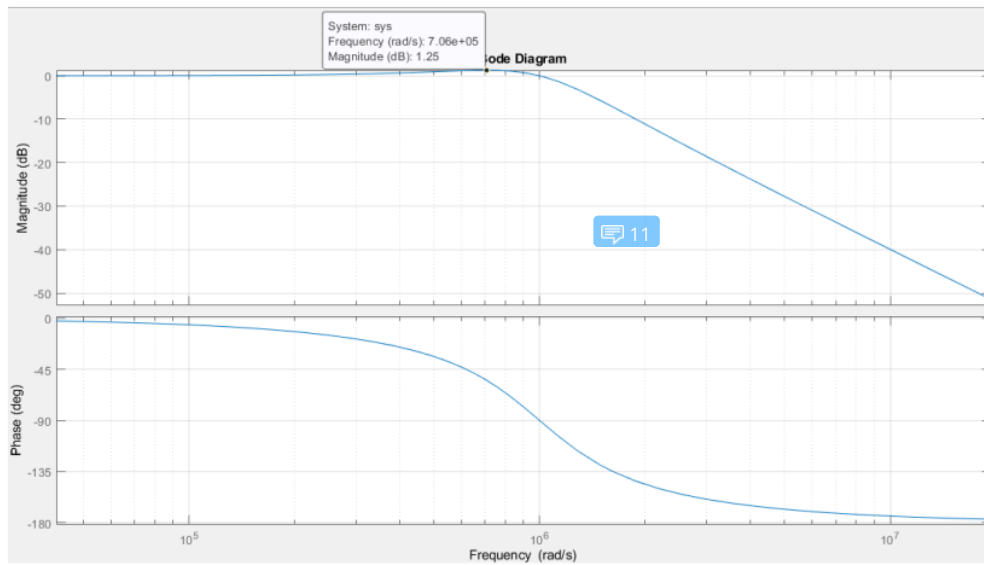
$\omega_m = \sqrt{(1/LC) - ((1/2)(R/L))^2} = \sqrt{(1 \times 10^{12}) - (2.5 \times 10^{11})} = 866025.4 \text{ rad/s}$

$\omega_o = (1/LC) = 1 / 0.001 \times (1 \times 10^{-6}) = 1000000 \text{ rad/s}$

$Q = (1/R) \sqrt{L/C} = 0.001 \sqrt{1000} = 0.0316$

$\Sigma = (R/2) \sqrt{C/L} = 500 \sqrt{(1 \times 10^{-3})} = 15.811$

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Task 8

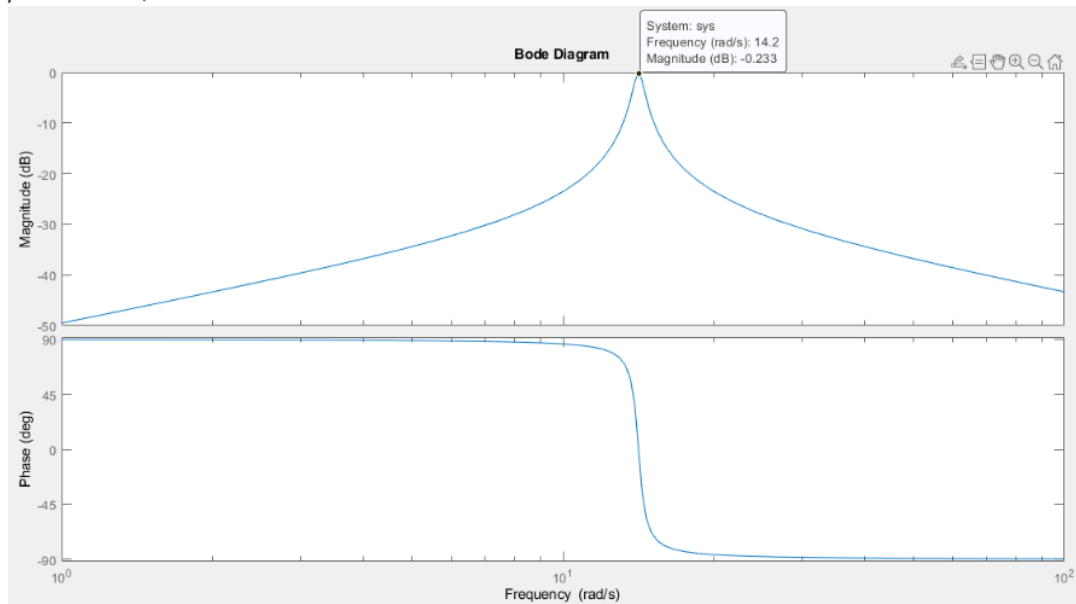
$R = 1500\text{ohms}$ $L = 5\text{H}$ $C = 1\text{mF}$

$$Y(s)/X(s) = (s \times \frac{2}{3}) / (s^2 + \frac{2}{3}s + 200)$$

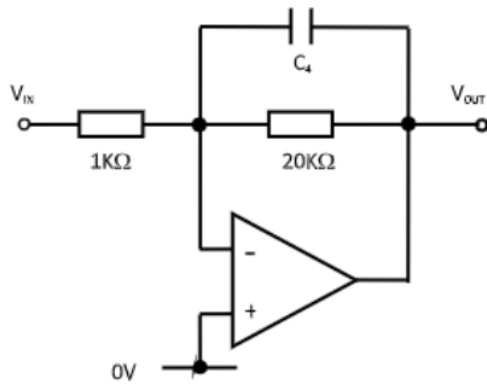
12

$$\omega_0 = \sqrt{200} = 14.14 \text{ Rad/s}$$

$$\beta = 0.666 \text{ Rad/s}$$



Task 9

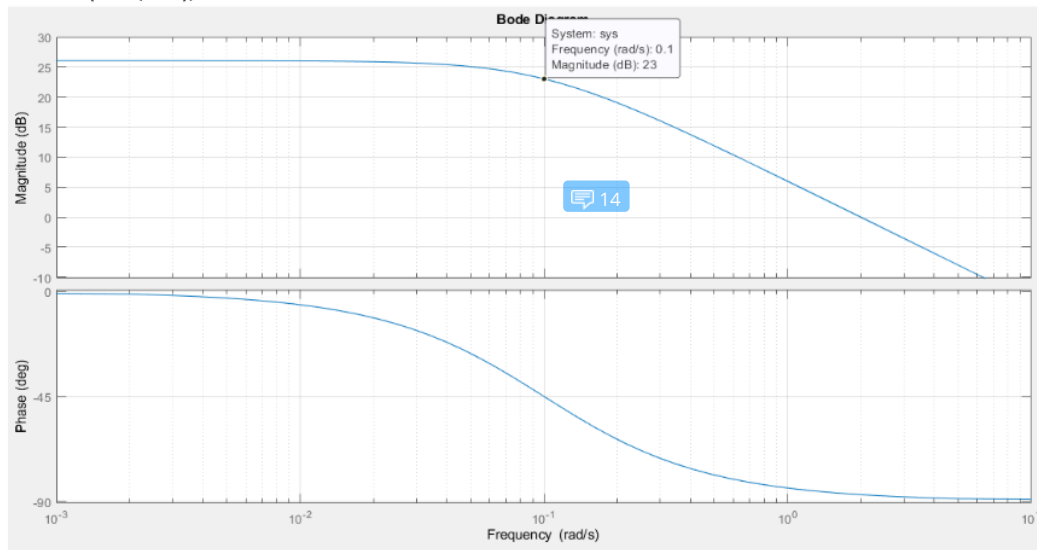


$C_4 = 500\mu\text{F}$ $R_1 = 1\text{k}$ $R_2 = 20\text{k}$

$\omega_c = 1 / (500\mu\text{F} \times 20000) = 0.1$

$K = 20000 / 1000 = 20$

```
>> num = [20*0.1];
>> den = [1 0.1];
>> bode(num,den);
```



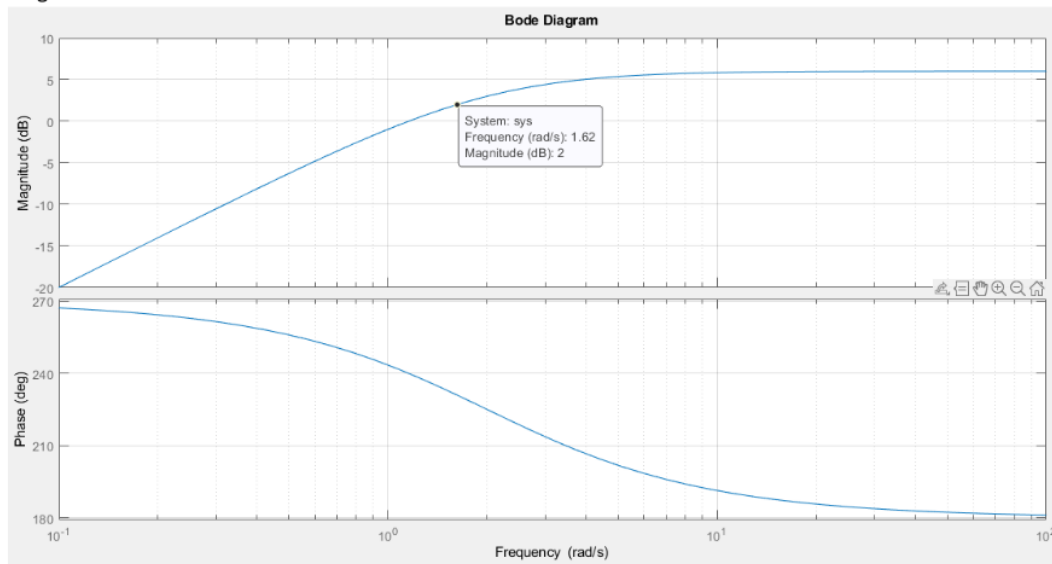
Task 10

$C5 = 500\mu\text{F}$ $R1 = 1\text{k}$ $R2 = 2\text{k}$

$$K = 2000 / 1000 = 2$$

$$\omega_c = 1 / (500\mu\text{F} \times 1000) = 2$$

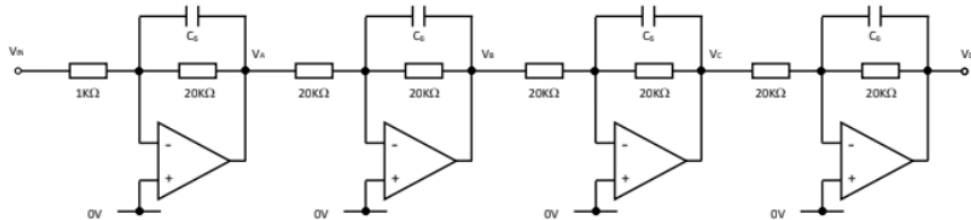
```
>> num = [-2 0];  
>> den = [1 2];  
>> bode(num,den);  
>> grid
```



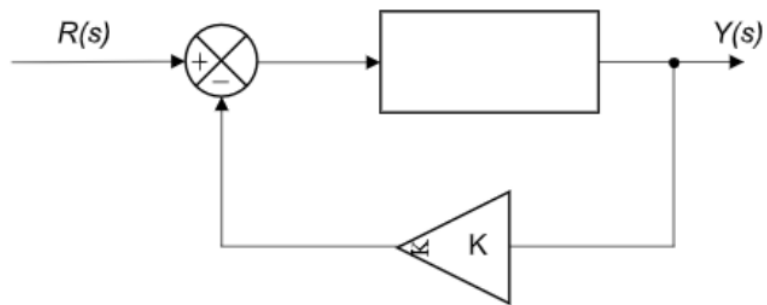
Task 11

$R1 = 1k$ $R2, R3, R4, R5, R6, R7, R8 = 20k$ $C1 = 50\mu F$ $C2 = 100\mu F$ $C3 = 200\mu F$

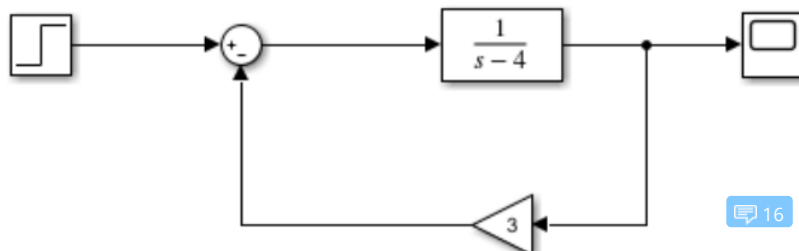
$C4 = 500\mu F$

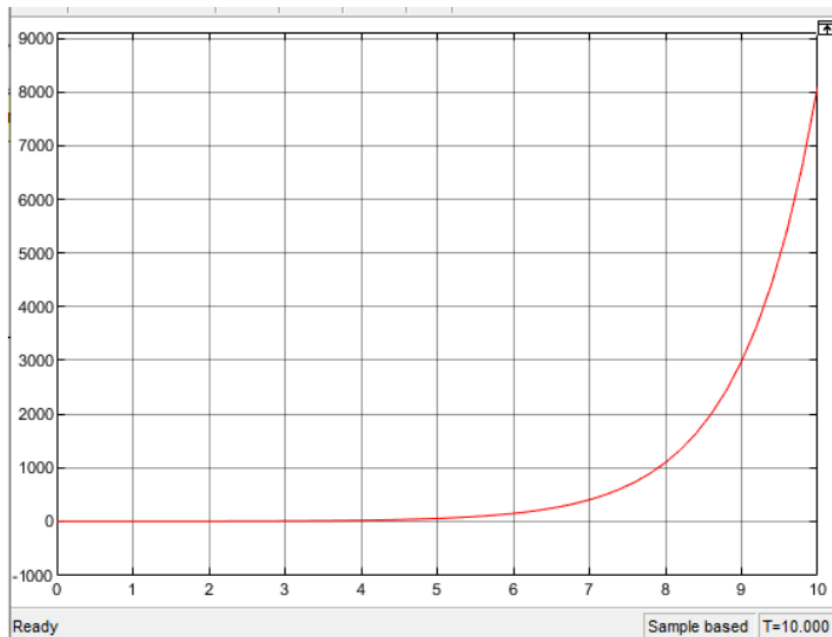


Task 12



Using this diagram, the following was produced on Simulink:





As can be seen from the graph above, when $K = 3$, it is unstable

Task 13

A DC permanent magnet motor has the following parameters:

Armature resistance = 1.5 Ohms

Armature inductance = 0.165H

Rotor inertia = 0.00042 Kg m²

Friction coefficient = 4.6×10^{-6} Nm/rad/s

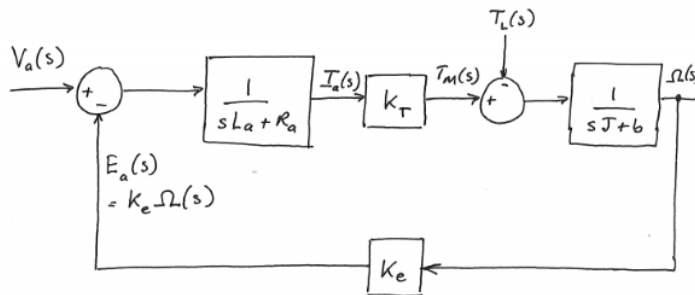
Motor voltage constant = 0.063 V/rad/s

Motor torque constant = 0.062 Nm/A

Maximum armature voltage = 24V

Symbols	Description	Units
v_a	Armature voltage	Volts
i_a	Armature current	Amps
R_a	Armature resistance	Ohms
L_a	Armature inductance	Henry
v_b	Motor back emf	Volts
T	Motor torque	N-m
I	Rotor inertia	kg-m ²
T_L	Load torque	N-m
ω	Angular speed of motor	rad/s
C	Damping coefficient	N-m-s/rad

Transfer function : $G(s) = (K_t / L_a J) / (s^2 + s (b/J + R_a/L_a) + (R_a b/L_a J) + (K_t K_e / L_a J))$



$$T_e = L_a / R_a$$

$K_{wn}^2 / s^2 + sZ_{wn} s + w_n^2$ compare this to 13.1

$$W_n^2 = R_a B / L_a J + K_t K_e / L_a J = 56.46$$

$$W_n = 7.51$$

You have worked this out correctly, well

$$2Z_{wn} = B/J + R_a/L_a \text{ solve for } Z(\text{sigma}) = 0.606 \text{ which is underdamped}$$

$$\text{Torque stall} = K_t V_a / R_a = 0.62$$

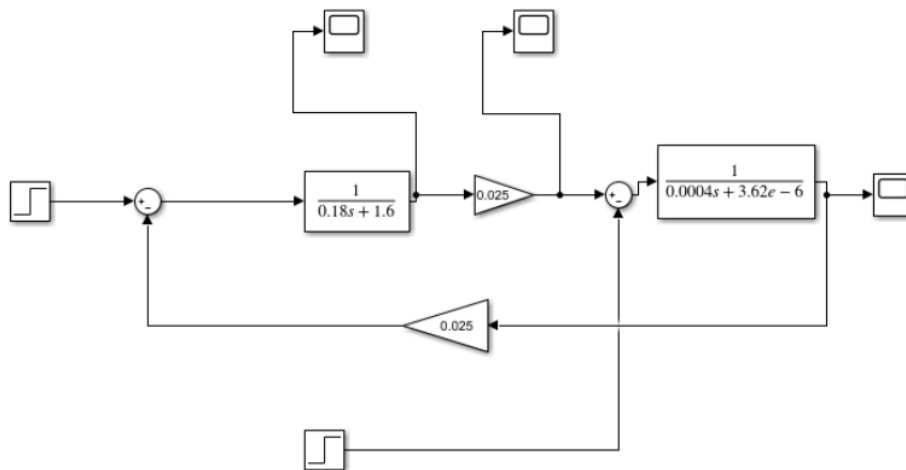
$$V_a = 15\text{v}$$

$$\text{Omega no load } V_a / K_e = 238.1$$

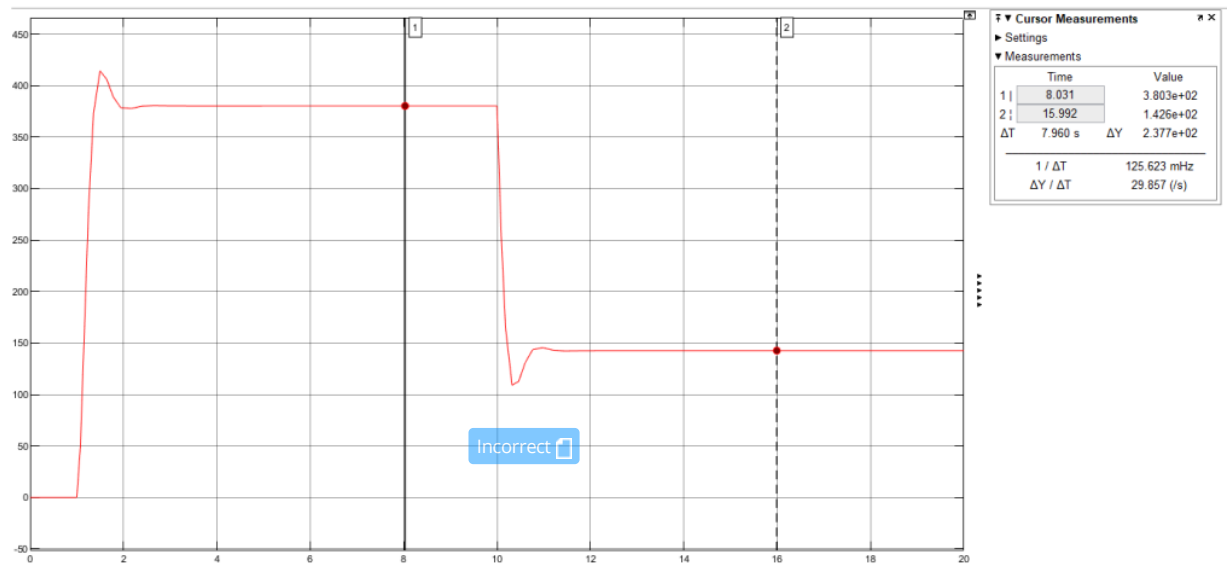
13.3 Plot the poles and comment on their location in the argand diagram.

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Using the previous values as well as using the transfer function, the following model was produced on Simulink:

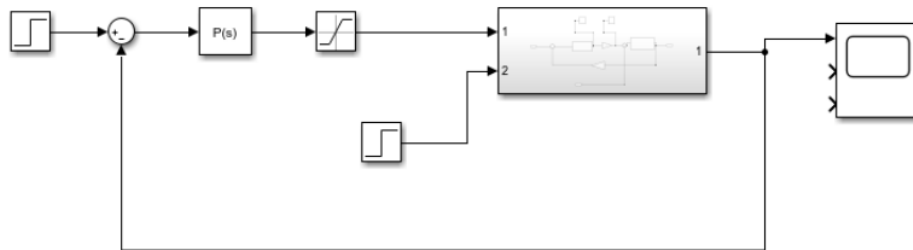


Using the model produced, simulations were carried out and monitored via graphing software in Simulink:

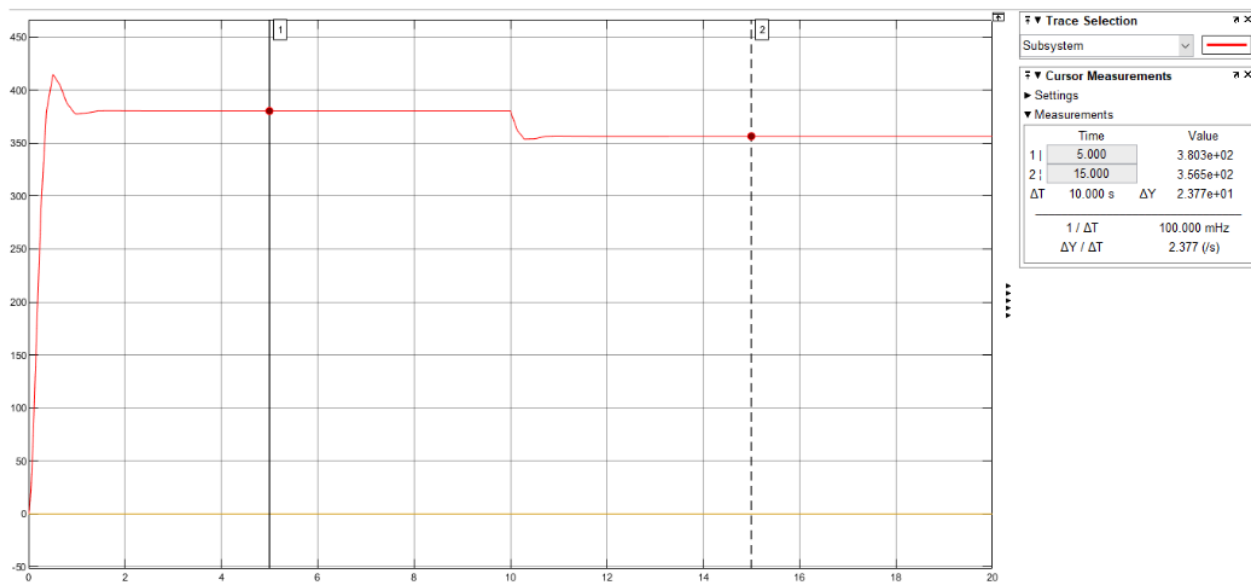


Task 14

Using the previously created models, the following model contains the previous motor model as a subsystem in order to test PID principles:

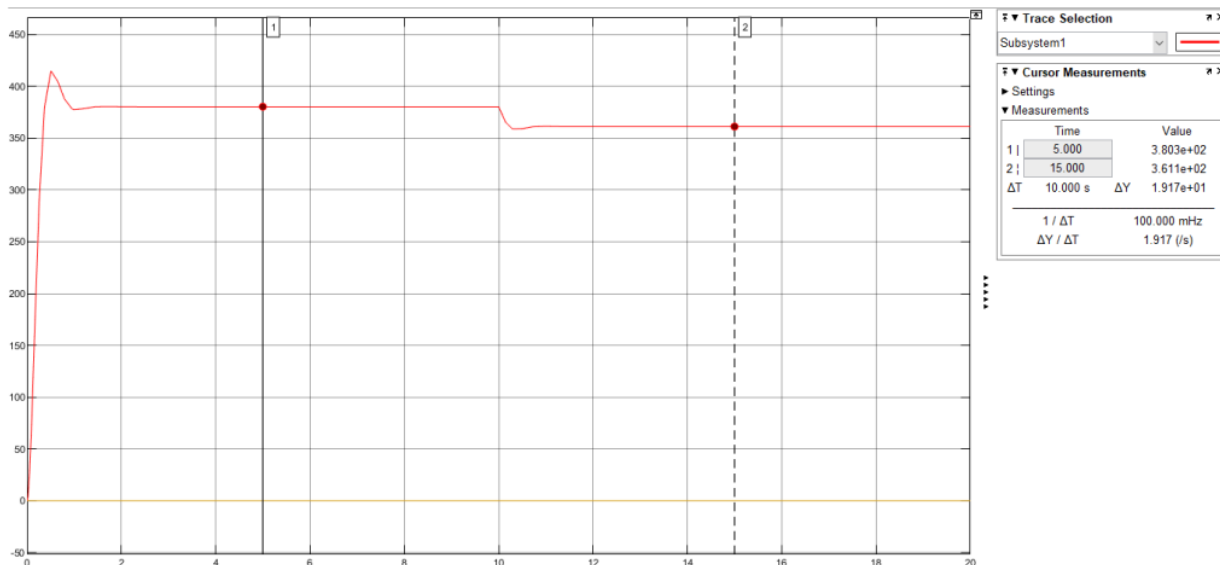
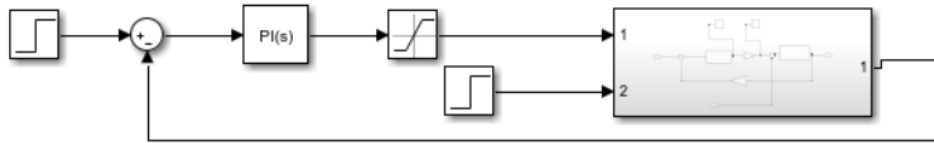


With the addition of the P, the graph produced had a much better value where it maintained torque more efficiently:



Task 15

Following on from the previous circuit, the integral part of the PID system was integrated and auto tuned in order to compensate for the current circuits discrepancies.



As can be seen from the above graph, the circuit performance has improved on from the previous.

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Task 16

Task 17

Task 18

As can be gathered from this assignment's desired completion on certain tasks, it was found that by applying different values to different components, even small adjustments, can greatly vary the results produced when analysed. This also highlights the usefulness of utilising simulation in order to gain a better understanding and design certain systems when compared to physical creating them for instead of having to repeatedly replace components, all that is needed is to change desired values in order to alter the circuit and thus the desired products, furthermore it can be considered that it's also much cheaper in the long term as certain components are much more expensive than others especially when looking for specific values such as 1 ohm resistors. Simulating designs does

have the drawback of not taking into account any tolerance variation in components or real-world inefficiencies such as temperature variation which would be remarkably difficult to simulate but not totally impossible. As previously alluded to, greater knowledge on how to use and apply simulation software was gained as well as the possibilities it can achieve.

assignment 1

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

40/100

PAGE 1

PAGE 2



Comment 1

use meaningful titles

PAGE 3



Incorrect

You have worked this out wrongly. It is not correct, check work more carefully.

Additional Comment

1st order only

PAGE 4



Comment 2

state the reason for measuring 0.632

PAGE 5



Incorrect

You have worked this out wrongly. It is not correct, check work more carefully.

Additional Comment

the output should decay

PAGE 6



Comment 3

task 3 incomplete



You have worked this out correctly, well



Comment 4

task 4 missing



Comment 5

under damped

PAGE 7



Comment 6

task incomplete, 4 cases of damping required



Comment 7

circuit?

PAGE 8



Comment 8

task incomplete



Comment 9

circuit?



Comment 10

check these answers

PAGE 9



Comment 11

measurements of ω_c , roll off phase etc?



Comment 12

where are the calculations?



Comment 13

where are the results and analysis?

PAGE 10



Comment 14

task incomplete

PAGE 11



Comment 15

incorrect and incomplete

PAGE 12



Comment 16

incorrect TF

PAGE 13

PAGE 14



You have worked this out correctly, well



Comment 17

?

PAGE 15



Incorrect

You have worked this out wrongly. It is not correct, check work more carefully.

Additional Comment

explain this graph? it does not match your calculated speed

PAGE 16



Comment 18

WW

PAGE 17



Comment 19

GRADING FORM: NEW CSG-RUBRIC

WILLIAM CAREY

40

1. ENGAGEMENT WITH LITERATURE



NA

2. KNOWLEDGE AND UNDERSTANDING



Knowledge is fragmentary, there is evidence of superficial understanding in that there are missing tasks and most tasks attempted are incomplete.

11/30

11

3. COGNITIVE AND INTELLECTUAL



Limited attempt at analysis, most tasks attempted are missing critical results and many errors exist.

12/30

12

4. PRACTICAL APPLICATION



Application of software is rudimentary with use of matlab and simulink attempted but not always used accurately to take essential measurements. 12/30

12

5. TRANSFERABLE SKILLS



Generally well communicated, however the report is incomplete. 5/10

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